PLANETARY SCIENCE

The Radiative Signature of Europa Ice

Galina M. Chaban, Timothy J. Lee, Winifred M. Huo

Recent observations from the Galileo satellite indicate that three of the Jupiter moons, Europa, Gandymede, and Callisto, may have subsurface oceans. Because water is an essential ingredient of life, the possible existence of the subsurface ocean and the nature of its composition is of great interest to planetary scientists and astrobiologists. Of the three moons, Europa has attracted the most attention. Data from the Galileo near-infrared mapping spectrometer (NIMS) indicate the possibility of hydrated salts on Europa's surface. The combination of a subterranean ocean, internal heat from tidal flexing, salt, and possible prebiotic materials from comet and meteorite impact may provide a possible condition for the formation and evolution of life. So far, the existence of both a subsurface ocean and hydrated salts is based on indirect evidence. The analysis of the NIMS spectra, for example, is based on the change of the water absorption spectra in hydrated salts in the 1.0 to 2.5-micron (μm) region. The assignment is by no means unique.

To search for a frequency range that can pinpoint the presence of salt more definitively, large-scale quantum chemistry calculations of hydrated magnesium sulfate, $MgSO_4$•nH_2O, n = 1–3, were made using second-order many-body perturbation theory and with a basis set of Gaussian functions at the triple zeta + polarization level. The configuration of the lowest electronic states of $MgSO_4$•$2H_2O$ and $MgSO_4$•$3H_2O$ are shown in figures 1 and 2. The wavelengths and intensities of infrared absorption for the SO_2 stretch modes are tabulated in Table 1.

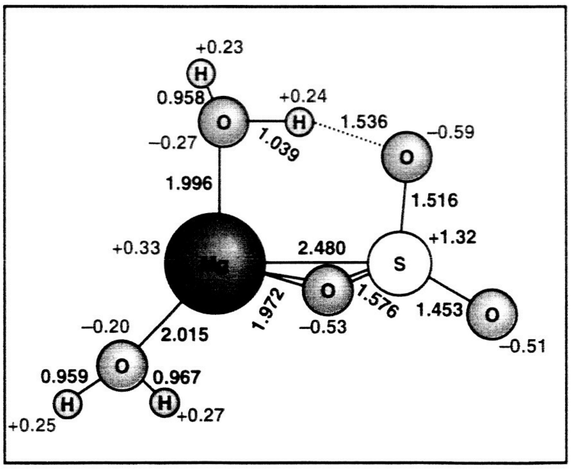

Fig. 1. Configuration of the lowest electronic state of $MgSO_4$•$2H_2O$.

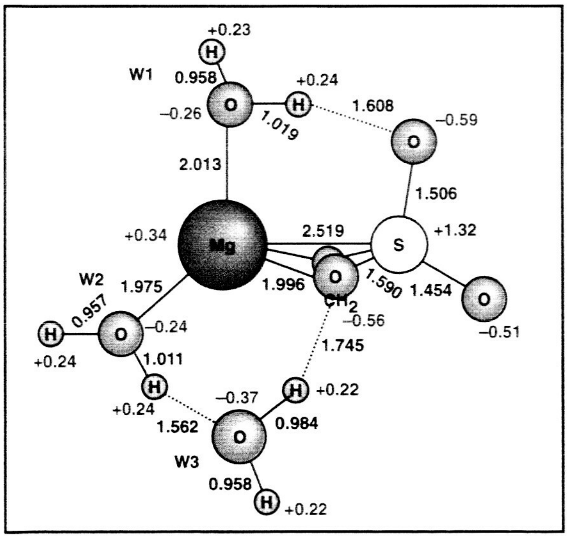

Fig. 2. Configuration of the lowest electronic state of $MgSO_4$•$3H_2O$.

Table 1. Wavelength and intensity of the SO_2 stretch modes for $MgSO_4 \cdot nH_2O$, n = 1–3.

Molecule	Vibrational mode	Absorption wavelength, μm	Intensity, Db^2/A^2 amu
$MgSO_4$	Asymmetric SO_2 stretch	7.424	7.01
	Symmetric SO_2 stretch	8.569	6.33
$MgSO_4 \cdot H_2O$	Free SO_2 stretch	7.502	8.90
	Bonded SO_2 stretch	9.911	10.95
$MgSO_4 \cdot 2H_2O$	Free SO_2 stretch	7.576	9.00
	Bonded SO_2 stretch	9.804	10.80
$MgSO_4 \cdot 3H_2O$	Free SO_2 stretch	7.593	8.48
	Bonded SO_2 stretch	9.372	9.00

The SO_2 stretch modes occur at longer wavelengths than the infrared absorption modes of water. They can serve as a unique identifier for the presence of magnesium sulfate salts. Interesting results were obtained on the infrared spectra of water bonded to magnesium sulfate. These results can be used to design a better detector for possible salts on the surface of Europa.

Point of Contact: W. M. Huo
(650) 604-6161
whuo@mail.arc.nasa.gov

Particle-Gas Dynamics in the Protoplanetary Nebula

J. N. Cuzzi, R. C. Hogan, A. R. Dobrovolskis

"Primitive"or unmelted asteroids, from which the planets were built, are represented in the meteorite record as a vast dataset that has had little context for interpretation. The accretion of these primitive bodies from small grains and millimeter-sized, melted "chondrules" almost certainly occurred in the presence of gas. Study of this stage is complicated by the feedback effects of the gas on the particles, and vice versa. Ames' efforts focus on numerical modeling of particle-gas interactions in turbulent flows, and understanding meteorite properties in the light of theoretical models.

The Ames "turbulent concentration" theory (TC), introduced several years ago, shows how particles of a specific size/density combination are concentrated by orders of magnitude in weak nebula turbulence. The theory makes specific predictions as to the relative abundance distribution of the concentrated particles. Predictions of the shape of the size distribution are in very good agreement with observed particle size distributions in primitive chondrites, thus revealing the fingerprints of TC. A multifractal theory has been developed to predict the magnitude of turbulent